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The diversity of butterfly communities in Southern Primorye*

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Abstract Butterfly communities were monitored at 8 points in Southern Primorye, Russia, from July to August in 1995. The number of individuals and species were surveyed by route census method at 4 points. As a result, the butterfly communities in Southern Primorye were similar to those in central Japan at an elevation of about 1,500 m a.s.l. So the species diversity in Southern Primorye was compared with those (Tashita and Ichimura, 1997) in Kamikochi (1,500 m a.s.l.) and lower region of Okumatashiro valley (1,650 m a.s.l.) in Azumi village, Nagano, central Japan, where plentiful nature with a primeval forest is protected as the national park. The species diversity in Southern Primorye was very high—from 3.46 to 4.39 in the average diversity (Shannon's H') (2.00 to 3.21 from July to August in Kamikochi and Okumatashiro valley), from 0.78 to 0.87 in the relative diversity (Pielou's J') (0.56 to 0.82 in Kamikochi and Okumatashiro valley). But the number of individuals in Southern Primorye was nearly the same as in Kamikochi and Okumatashiro valley, except that in Beresovyi stream surrounded by a primeval forest. Value of HI-index (Tashita and Ichimura, 1997) used to evaluate the natural environment of 8 points was lowest in the city of Vladivostok. But this level was the same as that in Saigawa riverside (Tashita and Ichimura, 1997) in Matsumoto, a habitat of *Tongeia fischeri, Lycaeides argyrognomon* and so on, and Higashifujigoko road (Sakuratani and Fujiyama, 1991) across the foot of Mt Fuji, a habitat of *Leptidea amurensis, Maculinea teleius* and so on, where good environment still remains. The species diversity in the environments where slight human action occurred (such as the lower reach of Losovy Range with yearly burn and Anishimovka along the railway and road) and HI values were slightly low, was higher than the primeval forest like Beresovyi stream where HI value was high, because many grassland species inhabit the moderately cultivated environments.

Key words Diversity, environmental evaluation, butterfly community, Southern Primorye, central Japan.

Introduction

It is important that we study the fauna of Southern Primorye in order to discuss about the foundation of the Japanese fauna. But until quite recently the reports about butterflies of Southern Primorye could hardly be gotten in Japan except "*Butterflies of the Far East*" written by A. I. Kurentsov (1970). We are very glad that Russian/Japan Cooperative East Asian Entomological Program started in 1990 and that recently several reports about the butterflies in Southern Primorye such as Takahashi (1996) and Yodoe (1996) were published.

The plentiful diversity of the insects in Southern Primorye is recognized by the reports such as Sibatani (1991*a*, 1991*b*) about butterflies and Mano (1992) about moths. But we have still not had a report analyzing the diversity in Southern Primorye by means of quantitative

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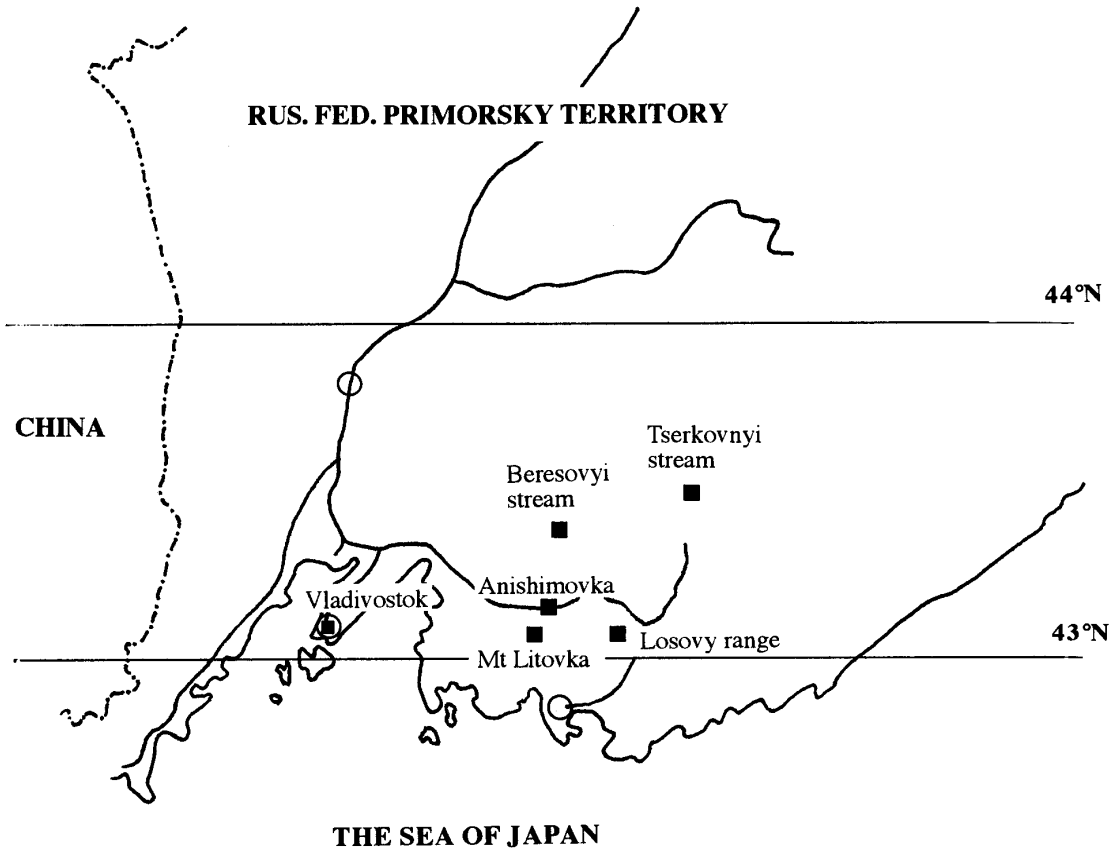

Fig. 1. Study sites.

method. We surveyed the butterfly communities in Southern Primorye, Russia by means of the route census method, and tried to compare the species diversity in Southern Primorye with that in central Japan. We could not fully assess the various habitats in this survey, and we hope that the detailed research of the butterfly communities will be carried out in Southern Primorye in the near future. For all of this survey tour, see the report of Nishio (1995).

Method

The butterfly species found in the study sites and the relative abundance (+ : about 1 individual per 30 minutes, ǂ : about 2–9, ǂǂ : 10–19, ǂǂǂ : 20–) of the individuals were recorded. The number of adult butterflies found in the 4 points, Beresovyi stream, upper and lower reaches of Losovy Range and Tserkovnyi, were recorded in the manner of route census surveys for 30 minutes (about 500 m in distance) in the daytime. This survey was practiced for 30 minutes from 11 : 30 to 14 : 30 under the light intensity of more than 25,000 lux, where many butterflies fluttered actively. As the route for the census a sunny place along a forest road was selected. Weather conditions (temperature, light intensity, humidity) were measured immediately before the route census.

The butterfly communities in 4 points surveyed were analyzed on the basis of the number of species and individuals. Average diversity (Shannon Weaver's function : H′) and relative diversity (Pielou's function : J′) indicated by Kimoto and Takeda (1989) are calculated as follows :

$$H' = -\Sigma(n_i/N) \log_2 (n_i/N)$$

Table 1. Study sites observed by route census method in Southern Primorye (1995).

study site	mark	altitude	vegetation	observation day	climate	light intensity	temperature	researcher
Beresovyi stream	BERE	450 m	primeval forest	July 15	fine	91,000 lux	24°C	M. Tashita
upper reach of Losovy range	CHAN-U	400 m	secondary forest	July 17	fine	54,000 lux	25°C	M. Tashita
lower reach of Losovy range	CHAN-L	300 m	secondary forest	July 17	fine	94,000 lux	28°C	M. Tashita
Tserkovnyi stream	TSER	450 m	primeval forest	August 4	cloudy	27,000 lux	26°C	A. Ono

N : total number of individuals
n_i : number of individuals of species $_i$

$J'=H'/\log_2 S$

S : number of species

Degree of overlap (Kimoto's function : CΠ) among study sites indicated by Kimoto and Takeda (1989) is caluculated as follows :

$C\Pi=2\Sigma n_{1i}n_{2i}/(\Sigma\Pi_1{}^2+\Sigma\Pi_2{}^2)\ N_1N_2$

$\Sigma\Pi_1{}^2=\Sigma n_{1i}{}^2/N_1{}^2,\ \Sigma\Pi_2{}^2=\Sigma n_{2i}{}^2/N_2{}^2$

N_1, N_2 : total number of individuals
n_{1i}, n_{2i} : number of individuals of species $_i$

A simple method using the HI-index, similar to the ER-index by Tanaka (1988), to evaluate the natural environment is presented by Tashita and Ichimura (1997). The value of this index ranges from 0 to 100 and indicates that the closer it comes to 100, the more native the butterfly habitats are in the observed places and the less the transformation by human agency occurred here. The HI-index is given as follows :

$HI=\Sigma n_iD_iF_i/(\Sigma 3n_iD_i)\times 100$

n_i : number of individuals of species $_i$
D_i : number of rank (0–3) of the i-th species' distribution
F_i : number of rank (0–3) of in kinds of food plants of the i-th species' larvae

The HI-index values in 8 survey sites were calculated by giving the relative abundance of individuals figures (+=1, ǂ=5, ǂǂ=15, ǂǂǂ=25).

Table 1 indicates the outline of the route census survey in Southern Primorye. It was cloudy in August 4, 1995. But many butterflies were fluttering actively.

Outline of the observed areas

1. Middle part of Beresovyi stream (Fig. 2 : A)

6 km W of Novaya Moskwa village. Rather narrow (no more than 1 km in width) valley, occupied by primeval mixed cedar-broad-leaved forest on alluvial-humic well-drained soil about 50 cm in depth, with deposits of gravel. The upper storey of forest is composed of *Pinus koraiensis*, *Betula costata*, *Ulmus propingwa*, *Populus maximoviczii*, *Quercus mongolica*, *Tilia amurensis*, *T. mandshurica*, *Fraxinus mandshurica*, *Crataegus maximoviczii*,

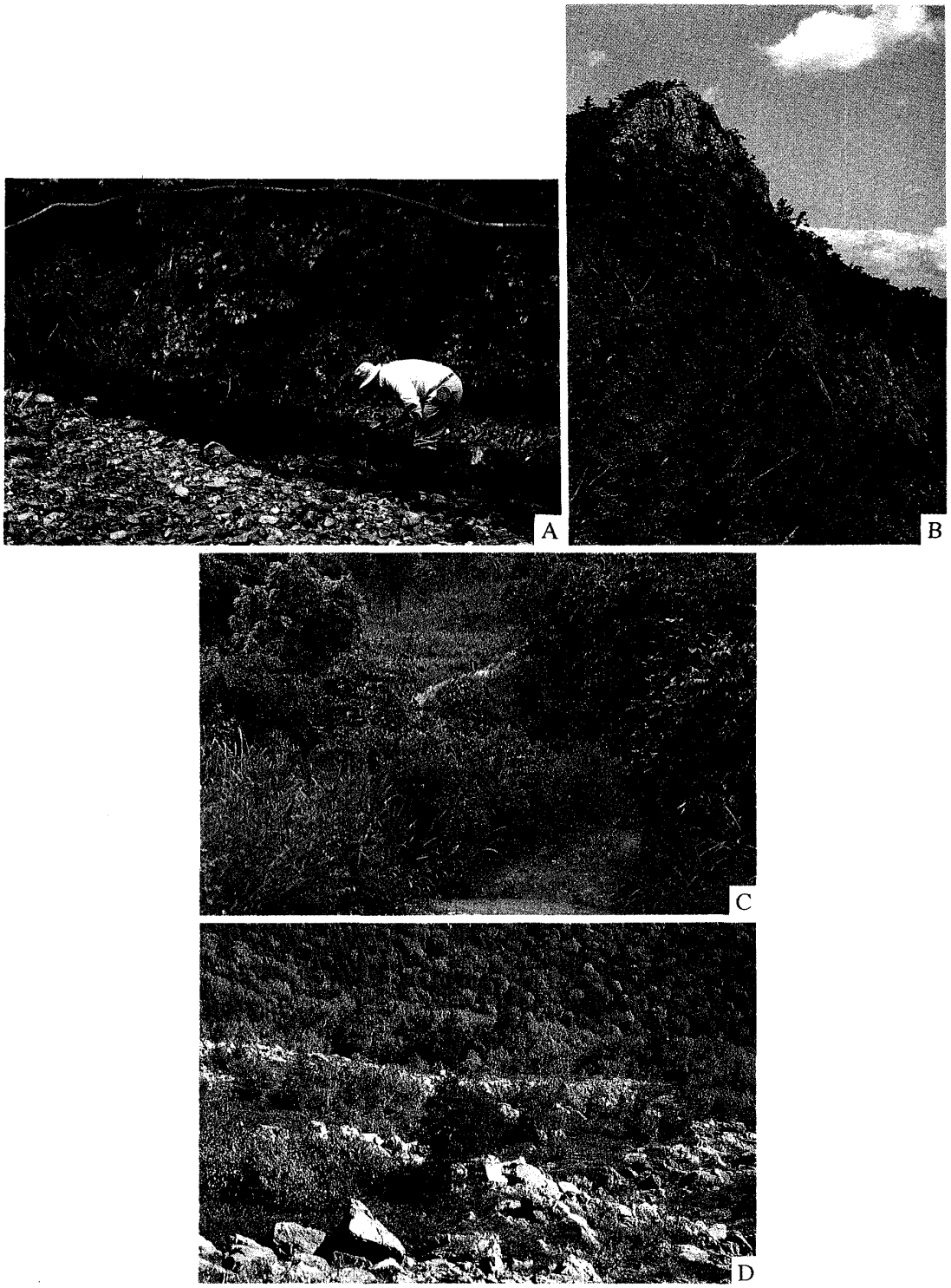

Fig. 2. Survey sites. A. Beresovyi stream. B. Upper reach of Losovy Range. C. Lower reach of Losovy Range. D. Range of Mt Litovka.

Maackia amurensis, *Syringa amurensis*. Undegrowth consists of lianas—*Vitis amurensis*, *Schisandra chinensis*, *Actinidia colomicta* and various shrubs: *Corylus heterophylla*, *Lonicera chrysanta*, *L. praeflorens*, *L. maackii*, *L. ruprechtiana*, *Ribes mandshurica*, *R. maximoviczianum*, *Philadelphus tenuifolius*, *Viburnum sargentii*, *Eleutherococcus senticosus*, *Euonymus maackii*, *E. sacrosancta* and others, typical for mixed broad-leaved coniferous forest. Grass cover is diverse, consisting of light-requiring (*Filipendula palmata*, *Caltha silvestris*, *Serratula coronata*, *Urtica angustifolia*, *Stellaria radians*, *Polemonium liniflorum*, *Rubia silvatica*, *Ligularia* sp., *Menispermum dahuricum*) and of shade-requiring (various ferns and sedges) plants. Weather conditions: The average highest temperature 19.2°C; the average lowest temperature −8.0°C; depth of snow 20–30 cm; rainfall 594 mm.

2. Losovy Range

8 km NW of Ekaterinovka village. Southeastern slopes of the ridge with outcrops of lime-stone. The locality is characterized by high isolation and extreme aridity, with alkaline reaction of soil. The rocky areas and accumulations around them of limestone gravel are occupied partly by occasional shrubs of *Juniperus rigida* and *Physocarpus ribisifolia* and some other specific petrophytes and xerophillous grasses: *Patrinia rupestris*, *Dianthus amurense*, *Gypsophila pacifica*, *Sedum middendorffianum*, *S. selskianum*, *Viola variegata*, *Platycodon grandifloras*. The sloping parts of the slopes are occupied mainly by sparse growth of *Quercus dentata* and *Q. mongolica* and wide meadows. The narrow ravines and northern slopes are covered with secondary oak-broad-leaved forest consisting of *Quercus mongolica*, *Tilia amurensis*, *Acer mono*, *Betula dahurica*, *Fraxinus rhynchophilla*, *Maackia amurensis*, *Corylus mandshurica*, *Philadelphus tenuifolius* and other shrubs, typical for mixed broad-leaved coniferous forest. The open parts of the slopes are covered with dense growth of *Lespedeza bicolor*, *Corylus heterophylla*, *Rosa davurica*, *Viburnum sargentii*, *Euonymus maackii*, *E. sacrosancta* and various grasses: *Miscanthus purpurescens*, *Spodiopogon sibiricus*, *Cimicifuga dahurica*, *Cacalia hastata*, *Clematis mandshurica*, *Doellingeria scabra*, *Cynanchum acuminatifoilium*, *Polygonatum involucratum*, *Filipendula palmata*, *Galium dahuricum*, *Vicia amoena*, *Lathyrus humilis*, *L. davidii* and others. Weather conditions: The average highest temperature 21.6°C; the average lowest temperature −7.8°C; depth of snow 6–7 cm; rainfall 594 mm.

Two sites were assessed, one (CHAN-U) being an upper reach of Losovy Range, the average altitude: 400 m a.s.l. (Fig. 2: B), and the other (CHAN-L) a lower reach with a stream, the average altitude: 300 m a.s.l. (Fig. 2: C).

3. Tserkovnyi stream

About 13 km N of Molchanovka village. Narrow valley in the upper part of Partisanskaya river, about 450 m a.s.l., occupied by primeval mixed cedar-broad-leaved forest. The bottom of the valley is composed of alluvial-humic soil about 30 cm in depth. The upper storey of forest consists of *Pinus koraiensis*, *Picea jesoensis*, *Betula costata*, *Ulmus propinqwa*, *Populus maximoviczii*, *Tilia amurensis*, *T. mandshurica*, *Fraxinus mandshurica*, *Acer mono* and *Phellodendron amurense*. In the second storey there are *Rhamnus davurica*, *Malus mandshurica*, *Crataegus maximoviczii*, *Maackia amurensis*, *Syringa amurensis*. Undergrowth consisits of lianas—*Vitis amurensis*, *Schisandra chinensis*, *Actinidia colomicta* and various shrubs: *Corylus heterophylla*, *L. maackii*, *L. ruprechtiana*, *Ribes mandshurica*, *Philadelphus tenuifolius*, *Viburnum sargentii*, *Eleutherococcus senticosus*, *Euonymus maackii*, *E. sacrosancta* and others, typical for mixed broad-leaved coniferous forest. The sides of

Table 2. Butterfly species observed in Southern Primorye (1995).

species	Beresovyi stream	Losovy upper	Losovy lower	Vladivostok	range of Mt. Litovka	Anishimovka near river	Anishimovka near railway	Tserkovnyi stream	parameter of HI-index	
	Jul/14 Jul/15 Jul/16	Jul/18 Jul/19	Jul/17 Jul/18 Jul/19	Jul/14	Jul/20	Jul/19 Jul/20 Jul/21	Jul/22	Aug/3	F	D
Daimio tethys		ǂ (2)							3	2
Satarupa nymphalis								(1)	3	3
Bibasis aquilina						ǂǂ			3	3
Heteropterus morpheus			ǂ (1)	+	+				2	1
Aeromachus inachus			ǂ (5)						3	3
Thymericus sylvaticus	ǂ		+			+			2	2
Ochlodes venatus	+	+	+						2	2
Ochlodes ochraceus	ǂ					+			2	2
Ochlodes subhyalinus		+ (1)	ǂ	ǂ					2	2
Carterocephalus sylvicola					+				3	3
Papilio xuthus	+ (1)		+ (1)						2	2
Papilio maackii	ǂ (3)		ǂ (1)		+	ǂ	+	(8)	3	2
Leptidea amurensis				+					3	3
Leptidea morsei			ǂ (2)			+	ǂǂ		3	3
Colias erate				+			ǂ		1	2
Pontia daplidice				+					1	2
Aporia hippia	ǂǂ (20)		ǂ			+	ǂ		3	2
Aporia crataegi	ǂ (4)		+	+		ǂ	+		2	1
Pieris rapae				+					0	3
Pieris napi	ǂ (2)	+	ǂ (2)	+		ǂ		(9)	3	2
Pieris melete			ǂ (1)	+					2	3
Pieris brassicae			+	ǂǂ		+			0	2
Ussuriana michaelis		+		+					3	3
Artopoetes pryeri	ǂ					ǂ			3	2
Antigius butleri						+			3	3
Chrysozephyrus smaragdinus						+			3	3
Favonius korshunovi						ǂǂ			3	3
Favonius latifasciatus						+			3	3

Favonius taxila	+++ (4)	+++ (3)	+++	+++		++++		(3)	3	2
Rapala arata	+ (2)								2	2
Fixsenia pruni	+								2	2
Fixsenia herzi	+								3	3
Nordamannia prunoides		++							3	3
Nordamannia w-album	+		+	+++		++			3	1
Lycaena phlaeas				+					1	3
Thersamonolycaena dispar			++ (1)	++			+		1	2
Glaucopsyche lycormas	+	+++ (7)	+++ (15)			+	++		3	3
Scolitantides orion			+						3	3
Celastrina argiolus	++ (4)	+ (1)	++ (1)	++				(2)	2	0
Everes arigiades	+	++ (2)	++ (6)	+		+	++		2	2
Lycaeides subsolanus	+	++	++ (3)				+		3	3
Lycaeides argyrognomon			+ (1)				+		3	3
Brenthis ino	++ (4)	++ (1)	+		+	++	++		3	3
Argyronome laodice			+ (1)						3	3
Argyronome ruslana			++ (6)						3	3
Argynnis paphia		++	+++ (18)			++		(1)	3	2
Childrena zenobia		+							3	3
Damora sagana			+					(1)	3	3
Fabriciana vorax		+ (1)	++ (1)						3	3
Fabriciana adippe		++ (1)	+						3	3
Speyeria aglaja		++ (9)	+ (1)			++			3	3
Mellicta ambigua		+	+						3	3
Arashnia levana		+ (1)	++ (2)			++		(12)	3	2
Polygonia c-album	++++ (27)	++ (1)	++ (4)			+++		(2)	3	2
Polygonia c-aureum	+							(1)	1	3
Nymphalis vau-album	++ (1)	+	++ (3)			+++		(10)	3	2
Inachis io	+	+ (1)	++ (6)		+			(5)	3	2
Aglais urticae	++ (5)		++ (4)		+++				3	2
Vanessa indica			++ (1)						3	2
Limenitis populi	++ (2)					++		(1)	3	2
Ladoga camilla	++ (3)					++		(1)	3	3
Ladoga helmanni	++ (2)		+						3	3
Ladoga amphyssa	+ (1)								3	3

Table 2. Butterfly species observed in Southern Primorye (1995).

species	Beresovyi stream	Losovy upper	Losovy lower	Vladivostok	range of Mt. Litovka	Anishimovka near river	Anishimovka near railway	Tserkovnyi stream	parameter of HI-index	
	Jul/14 Jul/15 Jul/16	Jul/18 Jul/19	Jul/17 Jul/18 Jul/19	Jul/14	Jul/20	Jul/19 Jul/20 Jul/21	Jul/22	Aug/3	F	D
Lodoga moltrechti	⋕ (12)	⋕ (2)	⋕ (2)			⋕			3	2
Ladoga homeyeri	⋕ (2)					+			3	3
Neptis philyra	⋕					+		(1)	3	3
Neptis philyroides	⋕								3	3
Neptis alwina			+ (1)	⋕					2	3
Neptis thisbe			+ (1)			+			3	3
Neptis themis	⋕ (3)					⋕			3	3
Neptis yunnanna	+								3	3
Neptis sappho			⋕ (7)						2	3
Neptis pryeri						⋕		(4)	3	3
Aldania raddei		+	+ (1)			+		(1)	3	3
Apatura iris	⋕ (3)	+ (1)	⋕ (3)			⋕		(1)	3	3
Apatura ilia	⋕ (30)	+ (1)	⋕ (1)			⋕			3	2
Apatura metis	⋕ (8)		+	+		⋕		(29)	3	1
Mimathyma schrenckii	⋕ (20)	+ (1)	⋕ (2)			⋕	+	(1)	3	3
Ninguta schrenckii								(2)	3	3
Ypthima argus	+					⋕	+	(1)	1	2
Aphanthopus hyperanthus	⋕ (6)		⋕	+		⋕	⋕	(1)	1	2
Lopinga achine	⋕ (11)	⋕ (12)	⋕ (4)			⋕			3	1
Melanargia halimede		+	+			+	⋕	(1)	2	2
Melanargia epimede	+	+	+			+	+		2	2
Coenonympha hero						+			3	3
Coenonympha oedippus						+	⋕		3	3
Minois dryas			+				+		2	2
Lasiommata deidamia		⋕			⋕				3	3
The number of species	(25)	(18)	(33)					(24)		
The number of individuals	(180)	(48)	(109)					(99)		

( ): The number of individuals per 30 minutes (500 m) counted by route census

Table 3. Diversity calculated by various index.

study site	H′	J′	HI	HI*
BERE	3.93	0.85	96.9	96.2
CHAN-U	3.46	0.83	96.8	97.8
CHAN-L	4.39	0.87	89.6	91.4
TSER	3.60	0.78	97.0	-
Vladivostok	-	-	-	59.2
range of Mt Litovka	-	-	-	99.4
Anishimovka (river side)	-	-	-	96.3
Anishimovka (railway)	-	-	-	84.8

* Calculated by abundant level (+=1, ++=5, +++=15, ++++=25).

Table 4. Degree of overlap (Kimoto's CII) among study sites.

	BERE	CHAN-U	CHAN-L
CHAN-U	0.2650	-	-
CHAN-L	0.1829	0.3718	-
TSER	0.1965	0.0506	0.1309

a road are covered with dense growth of *Sorbaria sorbifolia* and *Spiraea betulifolia*. Grass cover consists mostly of light-requiring plants (*Filipendula palmata*, *Caltha silvestris*, *Serratula coronata*, *Urtica angustifolia*, *Stellaria radians*, *Polemonium liniflorum*, *Rubia silvatica*, *Ligularia* sp., *Menispermum dahuricum*). Weather conditions: The average highest temperature 18.2°C; the average lowest temperature −8.8°C; depth of snow 30–45 cm; rainfall 550–600 mm.

4. Sedanka, vicinity of Vladivostok (Vladivostok)

Urban landscape in the suburb of Vladivostok with sanatoria, health resorts and private houses in very degraded and thinned out oak-broad-leaved forest, replacing native mixed coniferous forest. A soil almost entirely destroyed. Natural vegetation is represented by isolated trees of *Quercus mongolica*, *Fraxinus mandshurica*, *Juglans mandshurica*, *Phellodendron amurensis*, *Rhamnus davurica*, *Malus mandshurica*, *Crataegus maximoviczii*, *Maackia amurensis* and some shrubs, typical for oak-wood. In the sanatoria and health resorts some part of their territory is occupied by gardens and flower-beds with cultivated plants. The most part of the private domains is occupied by fruit-trees and kitchen-gardens. Weather conditions: The average highest temperature 18.4°C; the average lowest temperature −6.8°C; depth of snow 20–30 cm; rainfall 600–650 mm.

5. The range of Mt Litovka (Fig. 2: D)

About 12 km S of Anisimovka, stony deposit in the subalpine zone at the southern slope near the eastern summit of Mt Litovka, at elevation of 1,240 m a.s.l. The stony deposit is occupied partly by tapestry of prostrate shrub of *Microbiota decussata* and some dwarf shrubs (*Ledum decumbens*, *Rhododendron aureum*, *Cassiope ericoides*, *Vaccinium uliginosum*, *Arctous alpina*) or by shrubs of *Rosa acicularis* and sparse plots of grassy vegetation,

including mostly *Artemisia lagocephala*. This open place stretches far down almost to the foot and is surrounded from both sides by orophilic scrub forest consisting of scattered *Picea ajanensis*, *Betula lanata* and various shrubs, such as *Duschekia fruticosa*, *Syringa wolfii*, *Spiraea betulifolia* and *Lonicera edulis*. The clearings occupied with subalpine meadows are composed of *Calamagrostis langsdorfii*, *Veratrum alpestre*, *Hieracium coreanum*, *Geranium erianthum* and other high grasses. Some plots at the boundary of stony deposit with spruce forest are covered with tapestry of *Beringia pacifica* with other dwarf shrubs, too. Weather conditions: The average highest temperature 16.4°C; the average lowest temperature −12.6°C; depth of snow 40–60 cm; rainfall 650–680 mm.

6. Anishimovka along the river

8 km SSE of Anishimovka, the upper Beresovyi stream, 400 m a.s.l. Small meadow by the foot of the northern slope of Mt Litovka in the mixed coniferous-broad-leaved forest. The banks of the stream are occupied by narrow belt of riparian forest with old trees of *Populus maximowiczii*, *Ulmus propinqua*, *Chosenia arbutifolia*, *Alnus hirsuta* and *Svringa amurensis*. The opposite side of meadow is bordered by dense secondary forest on the place of an old felling, consisting of various broad-leaved trees: *Populus davidiana*, *Fraxinus mandshurica*, *Ulmus laciniata*, *Betula mandshurica*, *B. costata*, *Acer mandschuricum*, *A. mono*, *Maackia amurensis*, *Malus mandshurica*, *Juglans manshurica* and others. Underwood is composed of various shrubs (*Lonicera maackii*, *L. maximowizcii*, *Philadelphus tenuifolius*, *Ribes maximoviczianum*, *Eleutherococcus senticosus*, *Acanthopanax sessiliflorum*, *Corylus manshurica*, *Euonymus pauciflora*, *E. sacrosancta*), lianas (*Vitis amurensis*, *Schisandra chinensis*, *Actinidia colomicta*, *A. arguta*) and of young coniferous growth. The end of meadow adjoins the northern slope of the mountain, which is covered, as other nearest slopes, mainly with *Quercus mongolica*, *Tilia amurensis*, *T. mandshurica* and coniferous: *Pinus koratensis*, *Abies holophylla* with admixture of *Picea yesoensis*, *Abies nephrolepis* and trees of *Taxus cuspidata*. Weather conditions: The average highest temperature 17.6°C; the average lowest temperature −7.6°C; depth of snow 40–50 cm; rainfall 650–680 mm.

7. Anishimovka along a railway

3 km W of Anishimovka, bottomland meadow, adjoining steep open slope along a railway. The meadow is covered with various grasses (*Spodiopogon sibiricus*, *Cimicifuga dahurica*, *Cacalia hastata*, *Clematis mandshurica*, *Filipendula palmata*, *Vicia amoena* and others) and sparse growth of trees, lianas and shrubs typical for riparian forest: *Juglans mandshurica*, *Rhamnus davurica*, *Malus mandshurica*, *Crataegus maximoviczii*, *Vitis amurensis*, *Viburnum sargentii*. The neighbouring steep slope is covered with dense growth of *Lespedeza bicolor* and some xerophillous grasses: *Miscanthus purpurescens*, *Sedum middendorffianum*, *Viola variegata*, *Platycodon grandifloras*. Weather conditions: The average highest temperature 18.2°C; the average lowest temperature −6.8°C; depth of snow 20–30 cm; rainfall 650– 680 mm.

Results

The number of species and individuals recorded by the route census method, and the relative abundance of individuals are shown in Table 2. 88 species, belonging to 6 families were recorded in 8 studied sites. In the lower reach of Losovy Range, where the vegetation is burned every year, the number of the recorded species was largest (33 species by route census, 52 species totally). The number of individuals was largest in Beresovyi stream (180 individ-

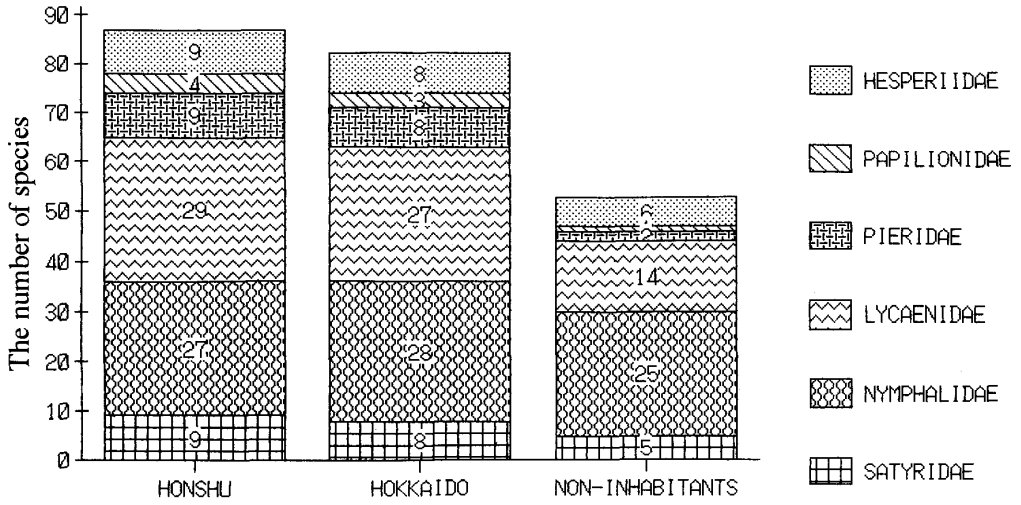

Fig. 3. The number of butterfly species distributed both in Japan (Honshu or Hokkaido) and in Southern Primorye (left and middle) and the number of Southern Primorye butterfiy species not inhabiting Japan (right).

uals per 30 minutes), where the primeval forest still remains. Though we could not evaluate 8 points equally by reason of the different survey time, the number of recorded species was smallest at the range of Mt Litovka (only 7 species), located around the ridge above the forest zone. The average diversity (Shannon Weaber's function : H′) was relatively high from 3.46 to 4.39 in 4 studied points. The value was highest in the lower reach of Losovy Range. The relative diversity (Pielou's function : J′) was also high from 0.78 to 0.87 in 4 studied points. This value was lowest in Tserkovnyi stream, where landscape is represented by the secondary forest (Table 3).

Degree of species overlap (Kimoto's function : CΠ) in 4 observed points was relatively low, ranging from 0.0506 to 0.3718. The highest value was recorded at the place nearest survey points between the lower and upper reaches of Losovy Range (Table 4). The butterfly communities in Southern Primorye largely change according to the habitat environment. The species most dominant in every studied site were as follows : *Apatura ilia* in Beresovyi stream, *Lopinga achine* in the upper reach of Losovy Range, *Argynnis paphia* in the lower reach of Losovy Range, *Favonius taxila* in Vladivostok and Anisimovka along the river, *Aglais urticae* at the range of Mt Litovka, *Leptidea morsei* in Anisimovka along a railway and *Apatura methis* in Tserkovnyi.

The influence of human actions was judged from the HI-index calculated from the host plants of the butterflies. The parameters F and D, the characteristics for the species, are shown in Table 2. Further, the HI-index was calculated in 7 points from the relative abundance (+ = 1, ǂ = 5, ǂǂ = 15, ǂǂǂ = 25). The value calculated from the relative abundance is fully similar to that calculated from the data of the route census in Beresovyi stream, the upper and lower reaches of Losovy Range (the HI-index in Tserkovnyi was not calculated from the relative abundance because of no records). The HI-index was lowest in Vladivostok, and this indicates that the human action is greatest in Vladivostok among 8 observed points. The second and third lowest values were marked in Anisimovka along a railway and road and in the lower reach of Losovy Range, respectively.

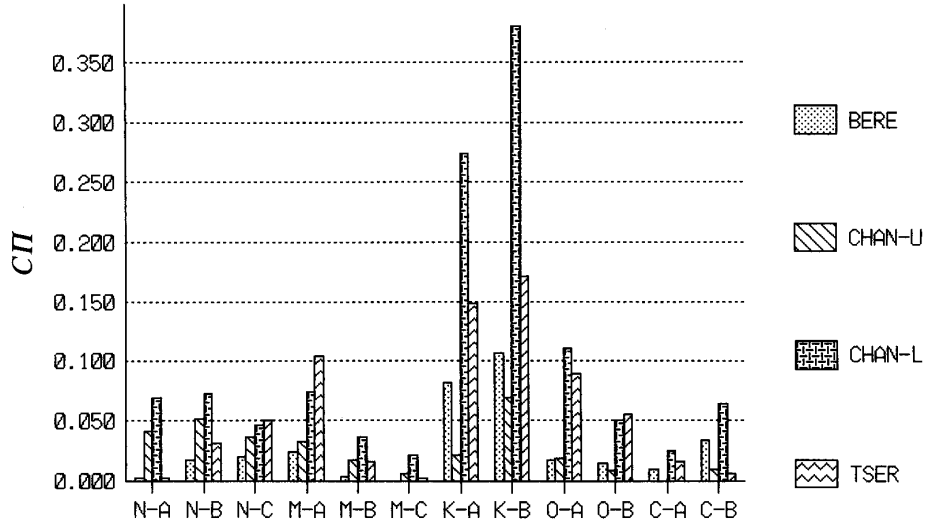

Fig. 4. Degree of overlap (Kimoto's CΠ) between study sites and Japan (Tashita, Ichimura, 1997) (butterfly communities of—N-A, N-B, N-C : Nagano city ; M-A, M-B, M-C : Matsumoto city ; K-A, K-B : Kamikochi in Azumi village ; O-A, O-B : Okumatashiro valley in Azumi village ; C-A, C-B : ridge of Mt Chogatake).

Discussion

1. The similarity with the butterfly communities in Japan

The total number of species found in Southern Primorye reaches 148 including the species found by Yodoe (1996) and Takahashi *et al.* (1996). The species inhabiting both central Japan (Honshu) or Hokkaido and Southern Primorye are enumerated in Fig. 3. The percentage of the species in central Japan or in Hokkaido against a total number (148) of species in Southern Primorye are 58.8% or 55.4%. The butterfly community in Southern Primorye is said to be similar to that in Hokkaido, and it is also similar to that in central Japan. The number of species distributed both in central Japan or Hokkaido and in Khabarovsk, located about 500 km N of Vladivostok, were 45 species (55.6% against a total number (81) of species) and 44 species (55.6%), respectively (Kamei and Umezu, 1995). Thirty-two species (39.5%) were not distributed in Japan. These ratios are very similar to those between Southern Primorye and Honshu or Hokkaido.

In the Nymphalidae, the percentage of the number of species not inhabiting Japan against those inhabiting central Japan or Hokkaido is much higher than in the other families. If the species prospering in Southern Primorye and not inhabiting Japan had almost spread over Southern Primorye after the Sea of Japan had been formed, it will be thought the nymphalid species have the ability to spread rapidly.

What altitude in central Japan is most similar to Southern Primorye in the butterfly communities ? The degree of overlap (Kimoto's function : CΠ) between the study sites in Southern Primorye and 12 points along the Shinanogawa river, central Japan (Tashita and Ichimura, 1997) is shown in Fig. 4. N-A, B, C in Fig. 4 are cold temperate zone (broad-leaved forest) about 350 m a.s.l. in Nagano city. M-A, B, C are cold temperate zone about 600 m a.s.l. in Matsumoto city. K-A, B are sub-alpine zone (coniferous-broad-leaved mixed forest) about 1,500 m a.s.l. in Kamikochi, Azumi village. O-A and O-B are sub-alpine zone about 1,650 m and 1,750 m a.s.l., respectively, in Okumatashiro valley, Azumi village. C-A,

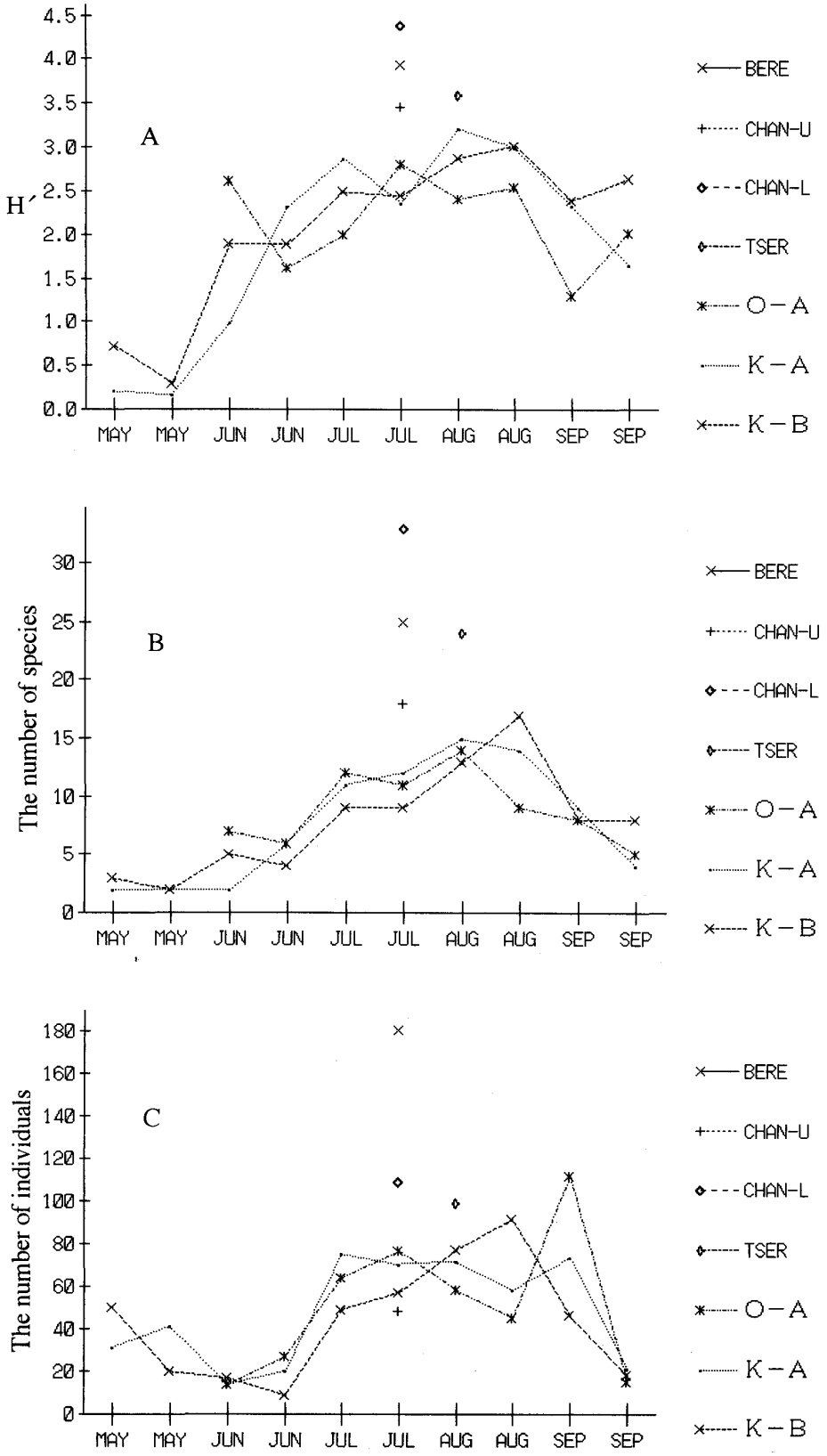

Fig. 5-A. Average diversity in study sites in Southern Primorye and central Japan.
Fig. 5-B. The number of species in study sites in Southern Primorye and central Japan.
Fig. 5-C. The number of individuals in study sites in Southern Primorye and central Japan.

B are alpine zone above timber line about 2,600 m a.s.l. in the ridge of Mt Chogatake. The degree of overlap between Southern Primorye and K-A, B is highest except for the upper reach of Losovy Range. It is suggested that the butterfly communities in Southern Primorye are most similar to those located about 1,500 m a.s.l. in central Japan (Fig. 4).

2. The diversity of butterfly communities in Southern Primorye

It is known in general that the lower the altitude, the higher the species diversity (Tashita and Ichimura, 1997). So the species diversity (the average diversity : H′) in Southern Primorye is compared with that in central Japan about 1,500 m a.s.l., where butterfly communities are the most similar. The average diversities (H′) in 4 points in Southern Primorye, Kamikochi-A, B and Okumatashiro-A from May to September are shown in Fig. 5-A. Wildlife in Kamikochi and Okumatashiro is now preserved carefully as a national park and natural monument under government, though it is heard that the forest had been cut about one hundred years ago. The average diversity in all of 4 points are higher than in Kamikochi-A, B and Okumatashiro-A (3.46–4.39 in Southern Primorye against 2.00–3.21 from July to August in Kamikochi and Okumatashiro). The relative diversity (J′) in Southern Primorye is also higher (0.78–0.87 in Southern Primorye against 0.56–0.82 from July to August in Kamikochi and Okumatashiro). The number of species and individuals registered for 30 minutes are shown in Figs 5-B and 5-C like Fig. 5-A. The number of species in Southern Primorye is larger, but the number of individuals is almost the same as in central Japan except in Beresovyi stream, where the primeval forest still remains. A lot of butterfly species tend to inhabit equally the same point in Southern Primorye, but total number of individuals is not always larger than in Japan.

The percentages of the number of individuals of grassland species in Southern Primorye and 12 points along the Saigawa river, central Japan, against the total number of individuals are shown in Fig. 6. The ratio is lowest in Beresovyi stream and Tserkovnyi, where primeval forest is growing. The ratio is relatively high in the upper and lower reaches of Losovy Range, where the vegetation is burned yearly. Conversely the ratio is relatively higher in Kamikochi-A, B, where the vast forest is preserved, than in Beresovyi stream and Tserkovnyi. We suggest a lot of grassland species are present in Kamikochi because the wide dry riverbed is formed, as the ratio of the maximum rainfall per one month against the minimum one is higher than in Southern Primorye (the annual rainfall is about 2,200 mm in Kamikochi and from 594 to 200 mm in Southern Primorye). Several species living in grassland were recorded along the forest road in Beresovyi stream and Tserkovnyi. The near-grassland species, that were recorded in the upper and lower reaches of Losovy Range, will be eliminated when succession of vegetation occurs following the cessation of human activity. It is suggested the diversity of the grassland species is preserved by moderate human actions as in the cases of declining species in Japan. But it is very difficult to understand why the species rapidly declining in Japan, such as *Lycaeides subsolanus*, *Coenonympha oedippus*, are normally abundant in the forest road across a vast area of forest. The number of species in the range of Mt Litovka is very little, and it is similar to that recorded for alpine zone in central Japan (Tashita and Ichimura, 1995).

3. Environmental evaluation in Southern Primorye

Some indicators used for butterfly communities are recently presented by Ishii *et al.* (1991), Kitahara and Fujii (1994), Nakamura and Toshima (1995) and so on, in order to evaluate natural environment. Tanaka (1988) proposed the existence ratio of environmental stage

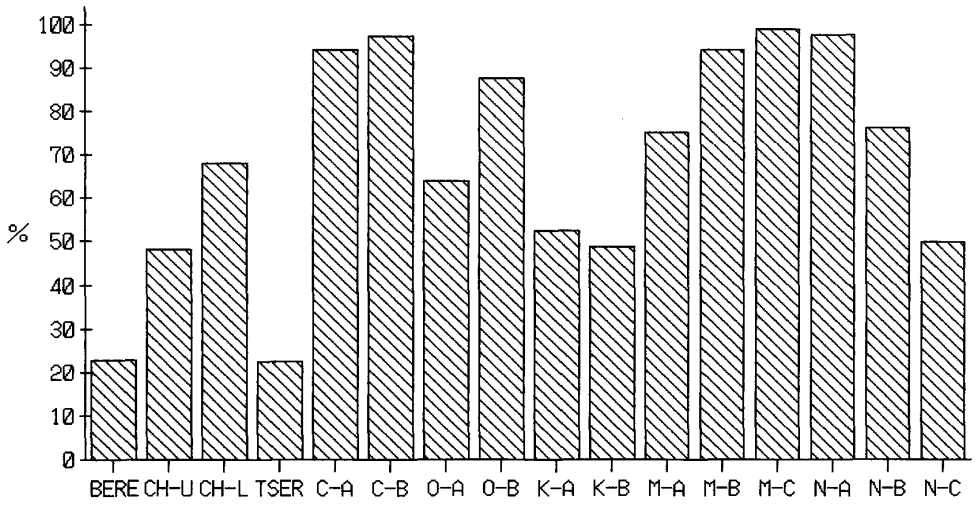

Fig. 6. Percentage of the number of individuals of grassland species against the total number of individuals.

(ER) to evaluate the transformation by human agency on the basis of the transect data. The environment is roughly classified into four stages. Habitat preference for these environmental stages is investigated for each species of the all Japanese butterflies. But it is difficult to apply Tanaka's ER to Southern Primorye because the habitat preference of each species of Southern Primorye's butterflies is not determined easily. So in this paper the environment in Southern Primorye was evaluated by Tashita and Ichimura's HI (1997) and compared with the values based on the butterfly communities of broad-leaved forest in cold temperate zone (Fig. 7). In Fig. 7 the HI value of Nikko-Utsunomiya road and Higashifujigoko road is calculated by Sakuratani and Fujiyama's transect data (1991). Nikko-Utsunomiya road is located in Nikko city, Tochigi Prefecture (600–700 m a.s.l.) and the forest, consisting of

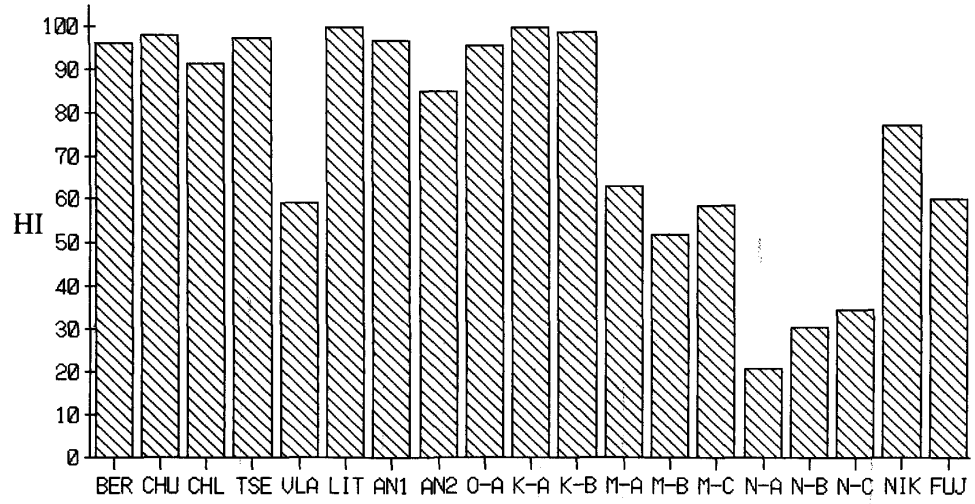

Fig. 7. Environmental evaluation by HI-index at study sites in Southern Primorye and central Japan (BER : Beresovyi stream ; CHU : upper reach of Losovy Range ; CHL : lower reach of Losovy Range ; TSE : Tserkovnyi stream ; VLA : Vladivostok ; LIT : range of Mt Litovka ; AN1 : Anishimovka along the river ; AN2 : Anishimovka along a railway ; NIK : along Nikko-Utsunomiya road ; EUJ : along Higashifujigoko road).

Quercus mongolica, *Q. serrata* and so on, is preserved as the national park. Higashifujigoko road is located near Kawaguchi lake, Yamanashi Prefecture (1,000 m a.s.l.) and surrounding this road is wide grassland of *Miscanthus sinensis* and so on, and secondary forest of *Pinus densiflora* and *Q. mongolica*. The HI value of Vladivostok, where human activity is at a high intensity, is almost the same as that of Matsumoto-A, B, C, the habitats of *Tongeia fischeri*, *Lycaeides argyrognomon* and so on, and Higashifujigoko road, the habitat of *Leptidea amurensis, Maculinea teleius* and so on, where good environment still remains. The HI value of Vladivostok is 30% higher than Nagano-A, B, C, near the center of Nagano city. Judging from the HI value, it seems that the environment of Vladivostok is preserved in good condition. The species diversity in the environment in which slight human activity occurs like the lower reach of Losovy Range, burned every year, and Anishimovka along a railway and road, where the HI values are slightly low, is higher including many grassland species than it is in primeval forest like Beresovyi stream, where the HI value is very high.

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摘　　要

ロシア沿海州におけるチョウ群集の多様性 (田下昌志・Yuri A. Tshistjakov・小野　章)

筆者らは，1995年7-8月にかけて，ロシア沿海州の8か所 (Fig. 1) においてチョウ群集の調査を行った．またそのうち4か所において，ルートセンサス法によるチョウの種類と個体数の把握を行った．

その結果，ロシア沿海州のチョウ群集は，日本中部のチョウ群集 (田下・市村，1997) と比較すると標高1,500 m付近のチョウ群集に一番類似していることがわかった．そこで，沿海州におけるチョウ群集の多様性について，原生に近い自然が自然公園として保護されている安曇村上高地 (標高1,500 m) と同村奥又白谷 (標高1,650 m) のチョウ群集と比較した．沿海州における種の多様性はとても高く，平均多様度 H′ (Shannon's H′) で3.46から4.39 (上高地，奥又白谷の7月から8月で2.00から3.21)，相対多様度 J′ (Pielou's J′) で0.78から0.87 (同0.56から0.82) であった．しかし，個体数は，原生林である Beresovyi stream では高かったものの，他の調査地では上高地，奥又白谷と同程度であった．次に，自然環境の状態を田中 (1988) の ER を簡略化した HI 指数 (田下・市村，1997) により比較した．個体数の記録がない3か所については，目撃頻度から HI の値を算出した．その結果，Vladivostok で8か所中最低となり都市化している状況を示した．しかし，その値は，ミヤマシジミやクロツバメシジミが生息する長野県松本市郊外の梓川堤防 (田下・市村，1997) やヒメシロチョウやゴマシジミが生息する富士五湖道路周辺 (桜谷・藤山，1991) の HI 値に近く，都市化はしているものの，まだ良好な自然環境が残されていることがわかる．人為的な火入れが行われている Losovy Range 下部や，鉄道・道路の周辺部である Anishimovka のような HI 値がやや低い場所は，原生林の Beresovyi Stream のような HI 値が高い場所よりも，多くの草原性の種類が生息し，種の多様性が高かった．

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